

## Gas Unit Quiz

$R=8.31 \text{ kPa}\cdot\text{L/molK}$	STP = 0 °C, 101.3 kPa	SATP = 25 °C, 100 kPa	Dry air is 80 % N <sub>2</sub> and 20 % O <sub>2</sub>
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- 8 1) A 1.00 litre of gas at STP is subjected to the following sequence of changes. Give V, P, and T after each change.
- a) P is increased to 250.0 kPa at constant T.  
 $V_2 = V_1 \times (P_1 / P_2) \times (T_2 / T_1) = 1.00 \text{ L} \times (101.3/250) \times 1 = 0.405 \text{ L}$
- b) T is then increased to 100. °C at constant P.  
 $V_2 = V_1 \times (P_1 / P_2) \times (T_2 / T_1) = 0.405 \text{ L} \times 1 \times ((100+273)/(0+273)) = 0.405 \text{ L} \times 1.37 = 0.553 \text{ L}$
- c) T is then decreased to 50.0 °C at constant V.  
 $P_2 = P_1 \times (V_1 / V_2) \times (T_2 / T_1) = 250 \text{ kPa} \times 1 \times ((50+273)/(100+273)) = 250 \text{ kPa} \times 0.866 = 216 \text{ kPa}$
- d) T drops by 50 °C and P increases by 100 kPa.  
 $V_2 = V_1 \times (P_1 / P_2) \times (T_2 / T_1) = 0.553 \text{ L} \times (216/316) \times ((0+273)/(50+273)) = 0.553 \text{ L} \times 0.684 \times 0.845 = 0.32 \text{ L}$
- 5 2) Which of the following calculations cannot be performed, as written, using the combined gas law?
- a) Calculate V<sub>2</sub> when 5.0 L of N<sub>2</sub> is pressurized from 50. kPa to 150 kPa at constant Temperature.  
**This can be done.**
- b) Calculate P<sub>2</sub> when air at 100 kPa at 100% humidity and 100 °C is cooled to 50 °C.  
**This will not work as most of the water vapour will condense.**
- c) Calculate P<sub>2</sub> in a rigid container containing wax vapor at 100 kPa when it is heated from 400 °C to 500 °C.  
**This will not work as wax molecules are too large and long to behave in an ideal gas.**
- d) Calculate V<sub>2</sub> when 20 L of Oxygen gas is heated to 100 °C.  
**The answer cannot be calculated as the initial temperature is not given.**
- e) Calculate the new volume of 5 L of ideal gas if it is heated from 50.01 °C to 50.02 °C.  
**This calculation can be made, but the precision of the temperature change is much less than the precision of the initial volume.**
- 1 3) Why is it necessary to use Kelvin temperatures in any ideal gas equation?  
**All of the equations are based on a temperature ratio, and ratio calculations require that an absolute number scale be used.**
- 4) 11.5 g of an elemental solid evaporates at 377 °C in a 2.00 L rigid container to exert a pressure of 125 kPa.
- 2 a) How many moles of gas are present?  
 $PV=nRT \quad n=PV/RT = 125 \text{ kPa} \times 2.00 \text{ L} / (8.31 \times (377+273)) = 250/5401.5 = 0.0463 \text{ moles}$
- 1 b) Assuming that the gas is approximately ideal at this high temperature, what is the molar mass of the gas?  
 $m_N = m/n = 11.5 \text{ g} / 0.0463 \text{ mol} = 248.5 \text{ g/mol}$
- 1 c) Assuming that the element forms a diatomic molecule in the gas state, what is the element?  
 $m_N / 2 = 248.5 / 2 = 124.25 \text{ g/mol}; \text{Iodine is the most likely element.}$
- 5) 15.0 g of Magnesium ribbon is burned to produce solid Magnesium oxide in a 10.0 L rigid container of normal air at 0 % humidity and at SATP. The reaction stops when *half* of the oxygen in the container is used up.
- 2 a) Which is the limiting reactant in this process?  
**If the reaction stops because of oxygen supply, oxygen must be the limiting reactant.**
- Explanation:**  
 (When the P<sub>O<sub>2</sub></sub> gets too low, the rate of combustion reactions can no longer sustain themselves)  
 Air is 20% oxygen. So, if the pressure is 100 kPa (SATP), then the P<sub>O<sub>2</sub></sub> must be 20 kPa.  
 Moles of oxygen would be  $n_{O_2} = P_{O_2} V/RT = 20 \text{ kPa} \times 10.0 \text{ L} / (8.31 \times (25+273)) = 0.0808 \text{ mol}$   
 Half of this gets used up, so 0.0404 moles of O<sub>2</sub> must have been used.
- 2Mg + O<sub>2</sub> → MgO** Therefore, 0.0808 moles of Mg (0.0404 /1 x2) would have been needed.  
 15 g of Magnesium is  $15 \text{ g} / 24.31 \text{ g/mol} = 0.617 \text{ moles}$ ; so Mg really was the excess reactant.

2 b) How many moles of oxygen are used up in the reaction?  
 1 **Air is 20% oxygen. So, if the pressure is 100 kPa (SATP), then the  $P_{O_2}$  must be 20 kPa.**  
**Moles of oxygen would be  $n_{O_2} = P_{O_2} V/RT = 20 \text{ kPa} \times 10.0 \text{ L} / (8.31 \times (25+273)) = 0.0808 \text{ mol}$**   
**Half of this gets used up, so 0.0404 moles of  $O_2$  must have been used.**

c) What mass, if any, of Magnesium remains in the container after the reaction?

**Moles of Mg present:  $15.0 \text{ g} \times 24.31 \text{ g/mol} = 0.617 \text{ mol Mg}$**

**Moles of Mg used:  $0.0404 \text{ mol } O_2 / 1 \times 2 = 0.0808 \text{ mol Mg}$**

**Moles of Mg left:  $0.617 - 0.0808 = 0.5362 \text{ mol Mg}$**

**Mass of Mg left:  $0.5362 \text{ mol} \times 24.31 \text{ g/mol} = 13.0 \text{ g}$**

1 d) Once the air in the container cools back to SATP, what will be the pressure inside the container?

**Since MgO is a solid, all that we have to worry about is how much  $O_2$  is used up.**

**Since half is used, the  $P_{O_2}$  will drop from 20 kPa to 10 kPa,**

**so the total pressure will drop by 10kPa from 100 to 90 kPa**

**Yes, I should have said cooled back to the *temperature* for SATP.**

6) A 0.26 g length of Magnesium ribbon is reacted with excess HCl to produce  $H_2$  gas, collected over water. 24.5 mL of gas is collected at a room and water temperature of  $21^\circ\text{C}$  and a room air pressure of 102.5 kPa.

2 a) What is the partial pressure of Hydrogen gas in the container?

**Since collected over water, there will be water vapour in the collected gas**

**From the chart below,  $P_{H_2O}$  at  $21^\circ\text{C}$  will be 2.49 kPa**

**$P_{H_2} = P_{\text{Total}} - P_{H_2O} = 102.5 \text{ kPa} - 2.49 \text{ kPa} = 100.01 \text{ kPa} = \underline{100.0 \text{ kPa}}$**

2 b) How many moles of Hydrogen gas were collected?

**$n_{H_2} = P_{H_2} \times V / (R \times T) = 100.0 \text{ kPa} \times 0.0245 \text{ L} / (8.31 \times (21+273)) = \underline{0.001 \text{ mol}}$**

2 c) What is the percent yield in this reaction?

**$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$**

**Therefore:**

**$n_{Mg} = n_{H_2} = 0.26 \text{ g} / 24.31 \text{ g/mol} = 0.01 \text{ mol}$**

**$\% \text{yield} = 100\% \times \text{actual yield} / \text{theoretical yield} = 100\% \times 0.001 \text{ mol} / 0.01 \text{ mol} = \underline{10\%}$**

7) The following reaction occurs at constant temperature and pressure:  $2C_2H_{6(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(g)}$

2 a) If 3.0 litres of  $C_2H_6$  is to be reacted, what volume of Oxygen gas is needed?

**$3.0 \text{ L} / 2 \times 7 = 10.5 \text{ L}$**

2 b) What volume of products will be made?

**$3.0 \text{ L} / 2 \times 4 = 6.0 \text{ L of carbon dioxide}$**

**$3.0 \text{ L} / 2 \times 6 = 9.0 \text{ L of water.}$**

3 8) Calculate the density of 1.00 L of gas mixture containing 30%  $CO_2$  and 70%  $C_2H_6$  by mole at SATP.

**$n_z = P_z \times V / (RT)$  or  $n_{\text{total}} = PV/RT$  using  $P_{\text{total}}$  then use  $n_z = n_{\text{total}} \times \% \text{ mole composition for gas}$**   
**‘z’**

**$n_{\text{total}} = 100 \times 1.0 \text{ L} / (8.31 \times (25+273))$**

**$= 100 / 2476.38$**

**$= 0.0404 \text{ mol}$**

**$n_{CO_2} = n_{\text{total}} \times 0.30 = 0.012 \text{ mol}$**

**$m_{CO_2} = n_{CO_2} \times 44.01 \text{ g/mol} = 0.53 \text{ g}$**

**$n_{C_2H_6} = n_{\text{total}} \times 0.70 = 0.028 \text{ mol}$**

**$m_{C_2H_6} = n_{C_2H_6} \times 30.08 \text{ g/mol} = 0.85 \text{ g}$**

**Total mass =**

**1.38 g**

**Therefore, the density of this gas is 1.38 g/L**

2 9) What pressure will be produced by 32 g of dry ice ( $CO_2$ ) if it evaporates into a 5.0 L tank at  $25^\circ\text{C}$ ?

**$n_{CO_2} = 32 \text{ g} / 44.01 \text{ g/mol} = 0.727 \text{ mol}$**

**$P = nRT/V = 0.727 \text{ mol} \times 8.31 \times (25+273) / 5 = \underline{360 \text{ kPa}}$**

1 10) 5 g of dry ice is placed into a rigid tank contains which contains Nitrogen gas at SATP. What will happen to the partial pressure of the Nitrogen gas as the dry ice evaporates. (the temperature in the tank stays constant)

**It will stay the same.**

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11) Two rigid tanks are connected by a valve. The first contains 5.0 L of  $N_{2(g)}$  at 200.0 kPa and the second contains 10.0 L of  $Ne_{(g)}$  at 50.0 kPa. Calculate the partial pressures and total pressure when the valve is opened.

$$P_2 = P_1 \times (V_1/V_2)$$

$$Ne: P_2 = 50 \text{ kPa} (10.0 \text{ L} / (10.0 \text{ L} + 5.0 \text{ L})) = 50 \times 0.666 = 33.3 \text{ kPa}$$

$$N_2: P_2 = 200 \text{ kPa} (5.0 \text{ L} / (10.0 \text{ L} + 5.0 \text{ L})) = 200 \times 0.333 = 66.7 \text{ kPa}$$

$$\text{Total Pressure: } 100.0 \text{ kPa}$$

#### Vapour Pressure Chart

19.0 °C	2.20 kPa	21.0 °C	2.49 kPa	23.0 °C	2.81 kPa	25.0 °C	3.17 kPa
20.0 °C	2.34 kPa	22.0 °C	2.64 kPa	24.0 °C	2.98 kPa	26.0 °C	3.36 kPa